ATV meeting – water and soil

Miljøfarlige kemiske stoffer – hvad er deres karakteristika, og hvordan undgår vi at skabe nye problemer?

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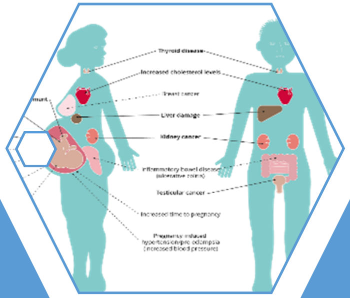
UNIVERSITY OF COPENHAGEN

This talk

Why worry about chemicals?

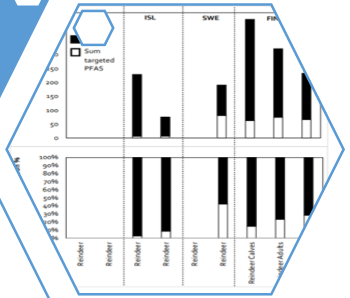
Characteristica of chemicals of concern



Chemicals Legislation

Chemical risk governance

Conclusions and Outlook



Chemical uses
- and concerns in Europe?

Europe is the second largest producer with **16.9%** of global sales

EU chemicals industry employs **1.2 million** people

59% of chemicals supplied to other sectors, such as health, constructions, automotive, electronics, textiles

84%

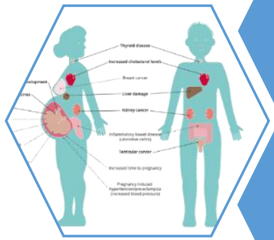
Europeans are worried about the impact of chemicals present in everyday products on their health

90%

Europeans are worried about the impact of chemicals on the environment

Soil improvers that contaminated a German community

An example..



PFAS in drinking water

Polluted soil and food

Polluted blood

Diseases?

House prices

Uncer-tainty

Lost income

Eco-system impact

Who to blame?

Health costs

Italy, Sweden, US..

Justice!

Industry?

Regula-tion?

Source?

Soil improver

Mill sludge

Clean up?

Filters on drinking water

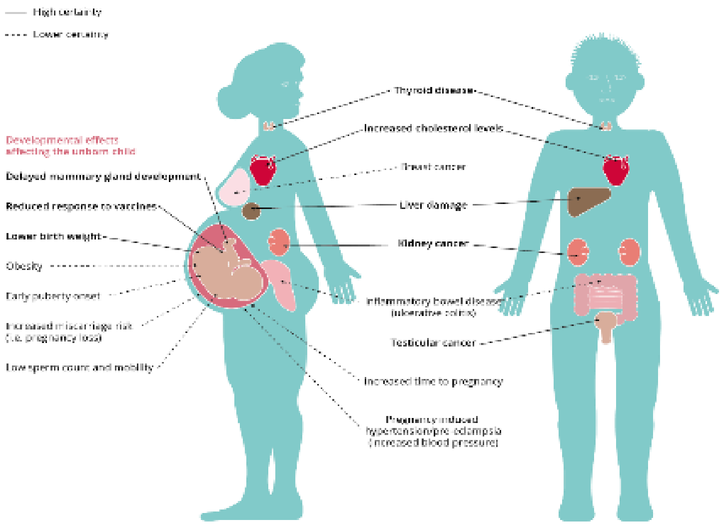
Soil?

Clean circular economy?

Safer chemicals!

Why care about chemical pollution?

- **We are surrounded by chemicals – some natural, some synthetic**
  - >100,000 chemicals in wider commercial use[1]
  - No. of chemicals increase, global production double by 2030
- **Some are toxic**
  - interfere with the healthy functioning of living organisms (humans, biota)
  - **Bioactive chemicals** – pesticides, pharmaceuticals, biocides, natural toxins, organohalogens..
  - Time of exposure – developmental endocrine/immune/neuro toxic effects may be irreversible; repeated exposures
  - **Mixtures**: Combined exposures of various chemicals stress living organisms

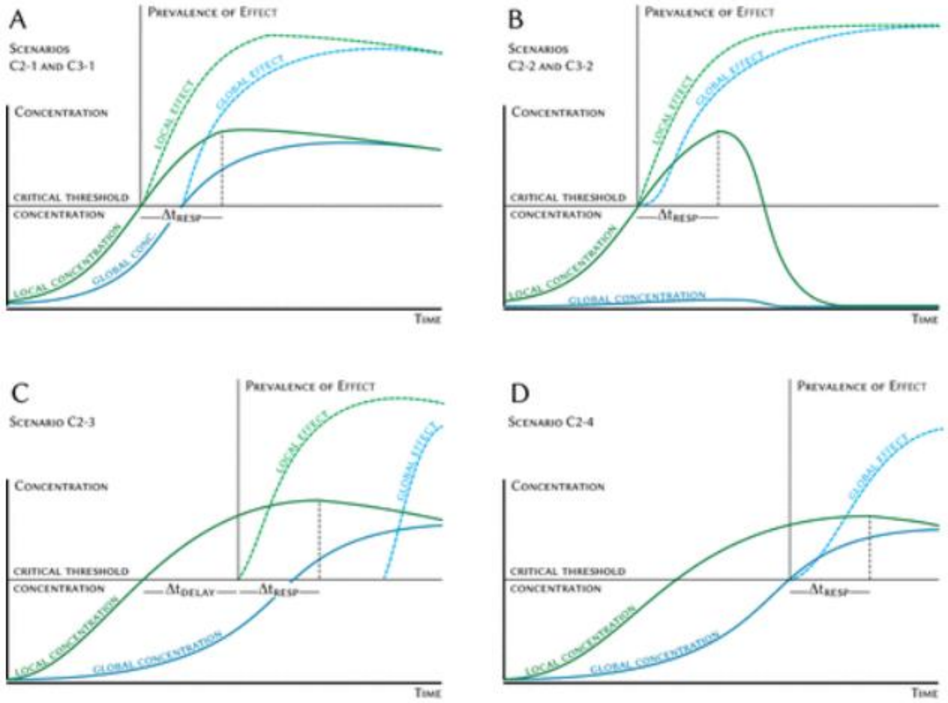


[1] State and Outlook of the Environment (SOER), EEA, 2020 – chapter on chemical pollution

Chemicals of concern: Harm to Earth systems

- **Chemicals with Planetary Boundary Threat characteristics** [1]
  - **Mobile**: move fast, so by time detected pollution has spread
  - **Persistent**: chemicals degrade slower than emitted => accumulate
  - E.g. ozone depleting substances (ODS), persistent greenhouse gases (CO2, F-gases)

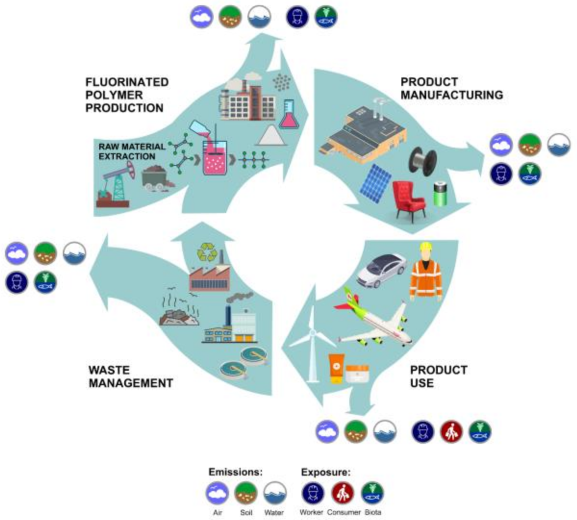
- **Chemicals causing irreversible pollution/effects are of most concern**

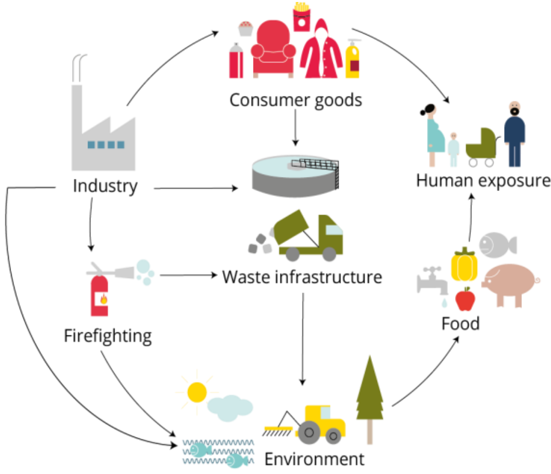


[1] MacLeod et al. (2014): Identifying chemicals that are planetary boundary threats

How do we get exposed?

- **Emissions along lifecycles**
  - Water, air, soil, food, products, workplace, skin/lung exposure
  - Circular economy
  - Climate change: Risks of remobilisations – flooding, fires, melting glaciers
- **Current and future chemicals of concern – some examples..**
  - PFAS/organohalogens – chlorinated parrafins/aliphatic acids: in dust, sludge, in biota, some in water
  - Surfactants used in high volumes – 'semi-persistent': Cationic (QACs, aquatoxic), neutral (detergents, dispersants)
  - Biotoxins – **'bio-pesticides'** – alkaloids and others *– cf. 50% reduction of 'chemical' pesticides*
  - Persistent and mobile (PM) compounds
  - Ionic liquids – solar panels, electronics, heat pumps

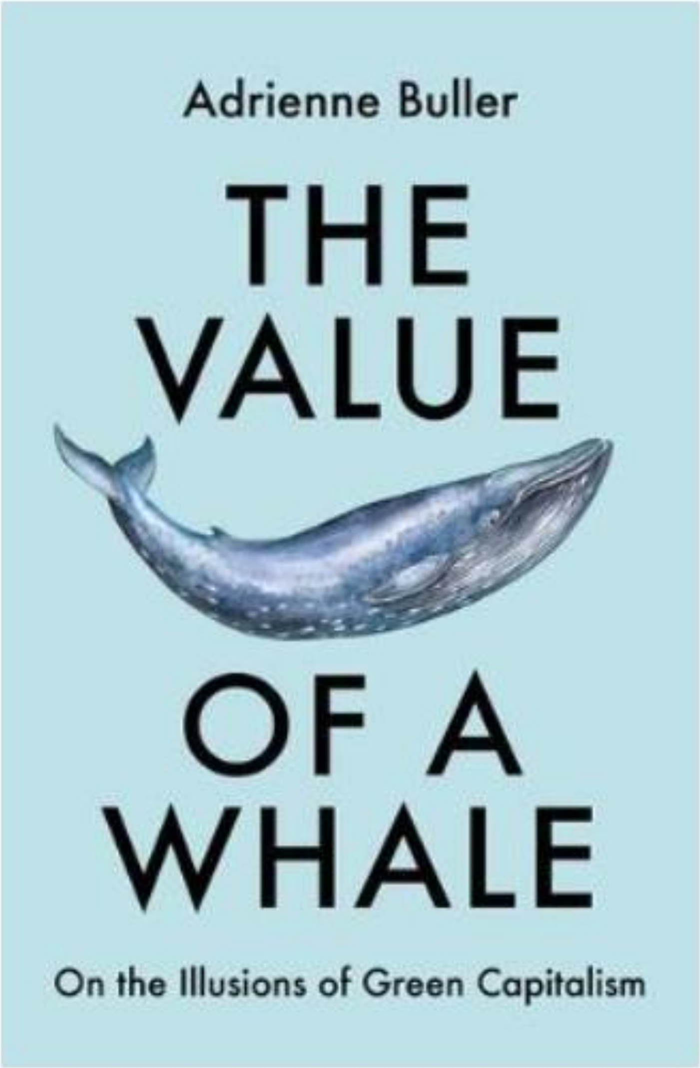




1 EEA (2019) Emerging risks of chemicals in Europe - PFAS . 2 EEA/ETC WMGE (20221) A systemtic view on fluorinated polymers in a low carbon, non toxic and circular economy

Ethical dimension?

- **Environmental justice – for people and nature?**
- **Who benefits from polluting – who bears the burden?**
  - Costs, health, ..
  - Through space (long range transport pollution), Through time (future generations)
  - Socio economically skewed
- **Rights of nature?**



[1] State and Outlook of the Environment (SOER), EEA, 2020 – chapter on chemical pollution

Risk Governance of Chemicals

- **Types: Prevention – Mitigation – Control – Remediation**

- **Risk governance by**
  - Legislations (international, EU, national) e.g. limit values, access to markets
  - Financial tools (taxes, insurance, branding, investments..)
  - Voluntary measures (by industry, citizens, labelling)

- **Emissions traditionally controlled by 'mitigation'**
  - Requires well functioning control systems and funding for enforcement
  - Future Challenges: Multiple natural and political crises
    => can we expect that funding for monitoring and enforcement will be prioritised?

Chemical legislation in Europe

- **EU regulations: >40 on chemicals, some transposed from international regulations**
  - Environmental legislation: Traditionally address emissions/presence of chemicals in media; some address uses, few address effects/risks to organisms.
  - Hazard, Exposure and Risk evaluations by ECHA, EFSA and EMA
  - Horizontal, e.g. REACH, CLP (Classification, Labelling and Packaging, EC 1272/2008)
  - Vertical, e.g. Industrial Emissions Directive (IED), European Pollutant Release and Transfer Registry (E-PRTR), Ambient air Water Frame Directive (WFD – incl. DWD/GWD), Urban and Industrial Waste Water Directives, Sewage sludge directive, waste directive, Detergents, Biocides Cosmetics and Personal care products, Pesticides, Veterinary Drugs, Food Contaminants, Food Contact Materials, Toys, Medicines, Sustainable Products Initiative (eco-design) etc. ..
- **International regulations, e.g.**
  - Criteria for hazard evaluations informed by e.g. OECD and Stockholm Convention on POPs
  - UNEP GHS – Global Harmonisation System; UNEP Stockholm Convention (SC) on Persistent Organic Pollutant (POPs); Long Range Transboundary Air Pollutants (LRTAP); UNEP Rotterdam convention (trade on hazardous chemicals), UNEP Basel convention (waste); WHO (air), Montreal Protocol (ODS, GHG) etc.
- **National regulations** – transposed from EU regulations, some specifications on e.g. soil, water limits

Example: PFAS regulations

from PFAS Staff Working Document, supporting the Chemicals Strategy for Sustainability (CSS)

Coherence between legislations?

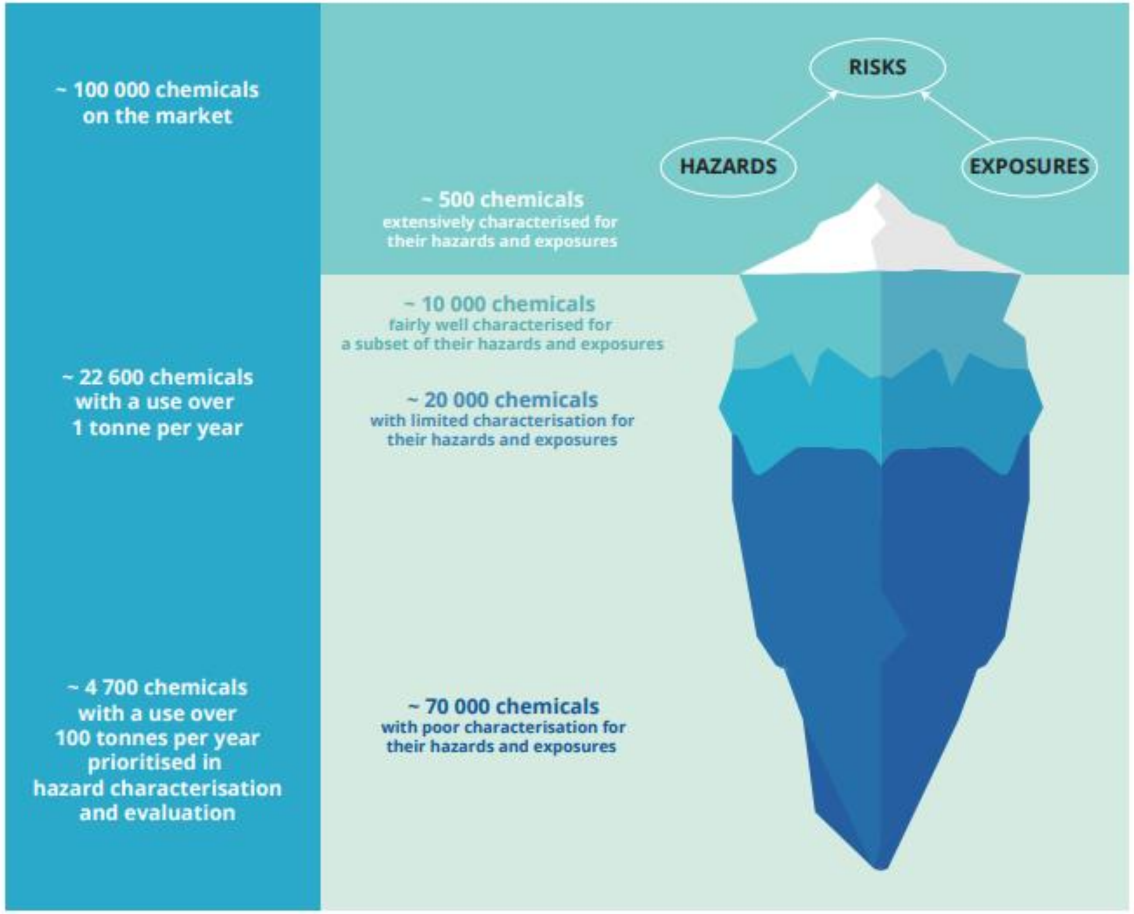
Courtesy: Valentina Bertato, DG ENV

https://ec.europa.eu/environment/pdf/chemicals/2020/10/SWD_PFAS.pdf

Risk Governance of chemicals – by risk assessment

- **Chemical risks = Hazard * Exposure**
  - Risk increases if either Hazard (toxicity) or Exposure (e.g. due to accumulated, persistent chemicals increase
  - Assumes 'pristine' environment
  - Generally does not consider mixtures and multiple stresses

- **Risk assessment cannot keep up with increasing no. of chemicals**



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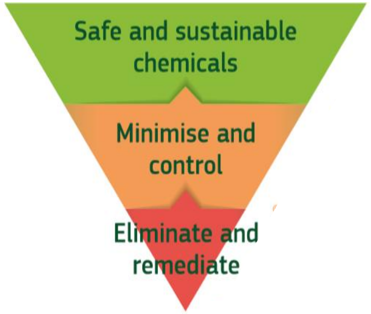


EU Chemicals Strategy for Sustainability (2020)
Preventing harm from chemicals

- **EU Chemicals Strategy: Part of the European Green Deal and the Zero Pollution Ambition - prevention rather than remediation, address groups of substances**
- **Addresses very persistent substances, with particular attention to PFAS as a class**
- **Define criteria for non-essential uses** to ensure that the most harmful chemicals are only allowed if their use is necessary for health, safety or is critical for the functioning of society and if there are no alternatives, and **phase out non-essential uses of most harmful substances**
- **Propose** new hazard classes and criteria in the CLP Regulation to fully address environmental toxicity, persistency, mobility and bioaccumulation
- Update legislations accordingly
- **Increase monitoring and reporting** of chemicals of concern

When to monitor chemical risks?

The International Risk Governance Council framework

IRGC. (2017). An introduction to the IRGC Risk Governance Framework

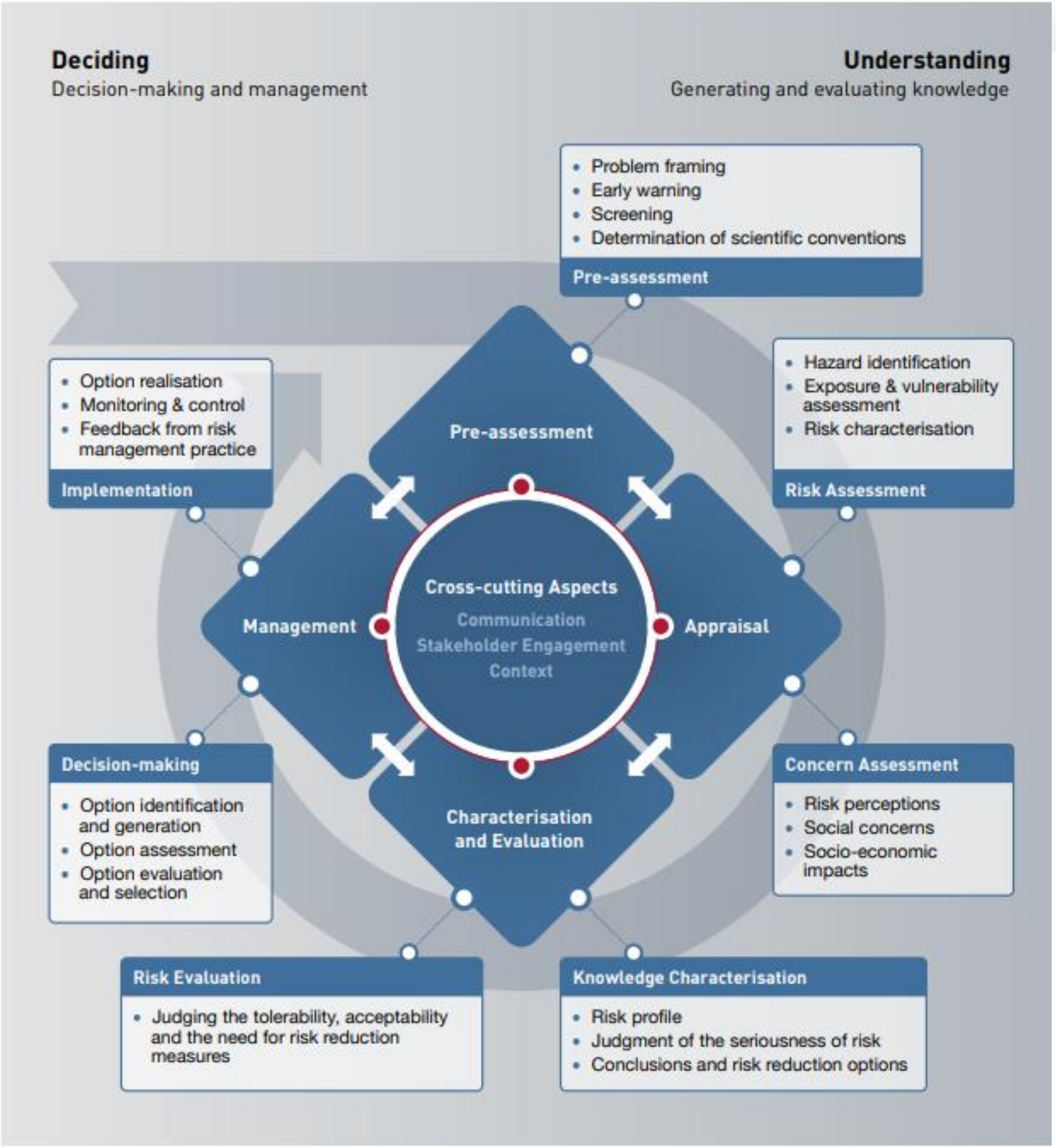
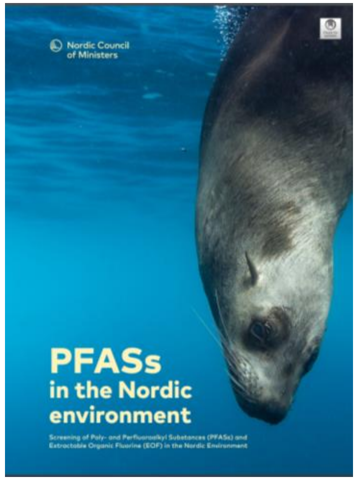
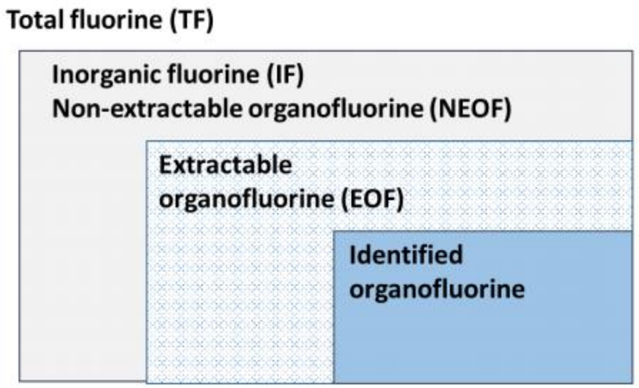


Figure 2: Detailed visual representation of the IRGC Risk Governance Framework.

Exposure to known and unknown groups of PFAS in marine biota/food



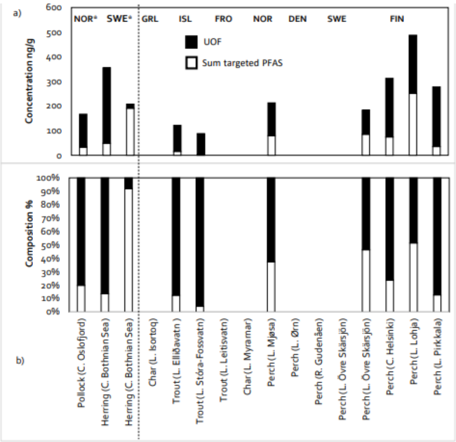


Methods:

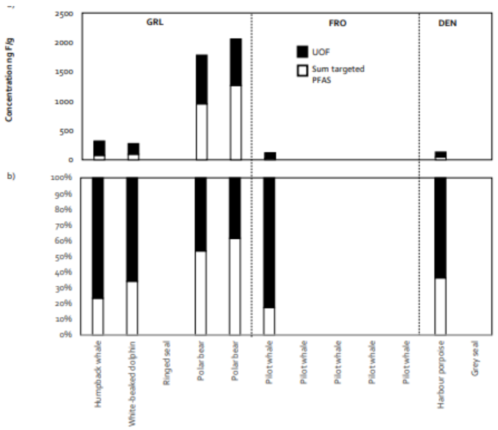
Total Organic Fluorine by EOF-CIC,
PFCA precursors by Total Oxidizable Precursors (TOP), LC-MS
– Non Targeted/Suspect Screening of PFAS?

- **White: Identified PFAS**
- **Black: Unidentified PFAS**

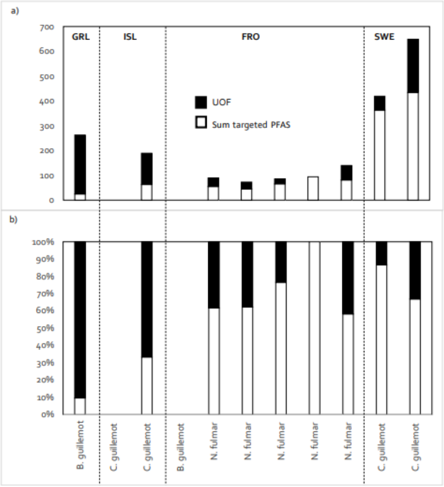
Fish



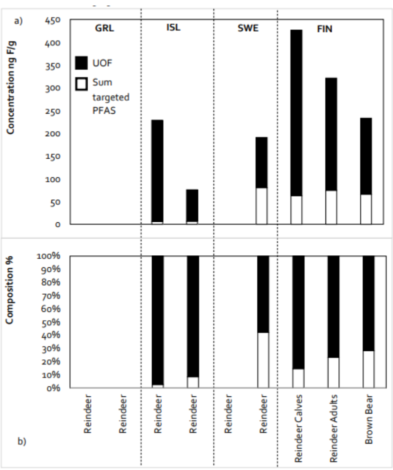
Marine Mammals



Bird eggs



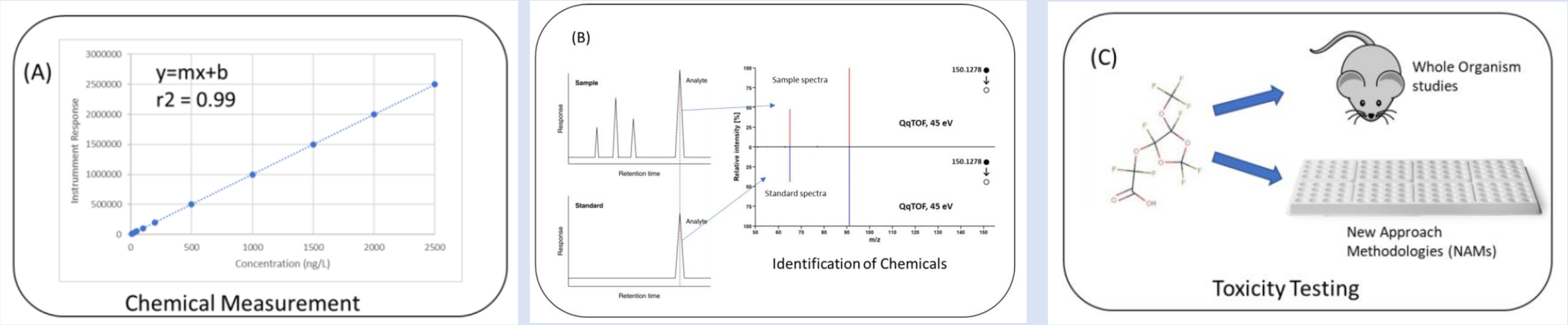
Terrestrial Mammals



[8] **PFAS in the Nordic environment (2019): https://norden.diva-portal.org/smash/get/diva2:1296387/FULLTEXT01.pdf**
[9] The importance of chemical analytical standards in risk governance of chemicals – *article in preparation 2022*

Quantification, Indentification and Hazard characterization requires access to chemical reference standards

- **Limit values typically based on risk assessment**
  => requires data on exposure (quantification/identification of substance), and hazard characterization
  => requires chemical reference standards
- **Confirmatory testing**: For control and enforcement, typically targeted analyses requiring chemical standards
- **Exploratory testing**: For surveys and early warnings; typically non-targeted/suspect screening analyses



The need for chemical reference standards to support science and policy,
Trier, Xenia[1],* van-Leeuwen Stefan P.J.[2]*, Brambilla Gianfranco[3], Weber Roland[4], Webster Thomas F[5], *Submitted to Environmental Health Perspectives, 2022*

Example of PFAS dilemmas: What to monitor?

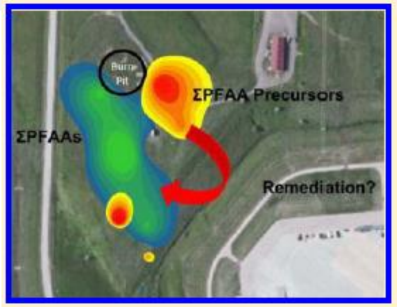
	PRO	CON
Analyse for single PFAS	Robust, confirmatory sampling/analyses methods	Overlook majority of PFAS => trouble later?
	Relatively cheap, fast/automated	Unmonitored pollutants may spread into water/food
	Limit values typically exist	Responsibility of ‘ignoring’ potential toxic pollutants?
	Substance ID can help identify source/polluter	Liability issues?
	Find less => less trouble now?	
Screen for more PFAS	More PFAS and transformation products can be found	Chemical identification/quantification hampered by lack of reference standards => lower certainty in RA
	Assist detection of source/polluter	Completeness of detection depends on analyses (e.g. GC or LC methods)
	Prevent pollution and source spreading	Expensive, time consuming

Backhaus and Trier (2015) Empowering academic research in chemical risk assessment and management, IEAM, 11 (2), https://doi.org/10.1002/ieam.1630

Example of PFAS dilemmas: What to monitor?

	PRO	CON
Analyse for PFAS total	All PFAS can be included (e.g. TF), a subset (e.g. EOF-CIC, 19F NMR, or surface e.g. PIGE, XRF)	Substances not known => 1. source identification not facilitated 2. how to interpret health risk? 3. which actions are justified? 4. communication to citizens hampered
	Relatively cheap and fast	Landowner get more 'trouble'/ clean-up costs now by knowing?
	Some limit values exist	
	Exceedance of limit can trigger polluter to pay for further investigations	
	Early warning => early action to limit pollution and make polluter pay?	
	Easy to communicate result in 'supply chain'	

Esxample of PFAS dilemmas: To clean up or not?



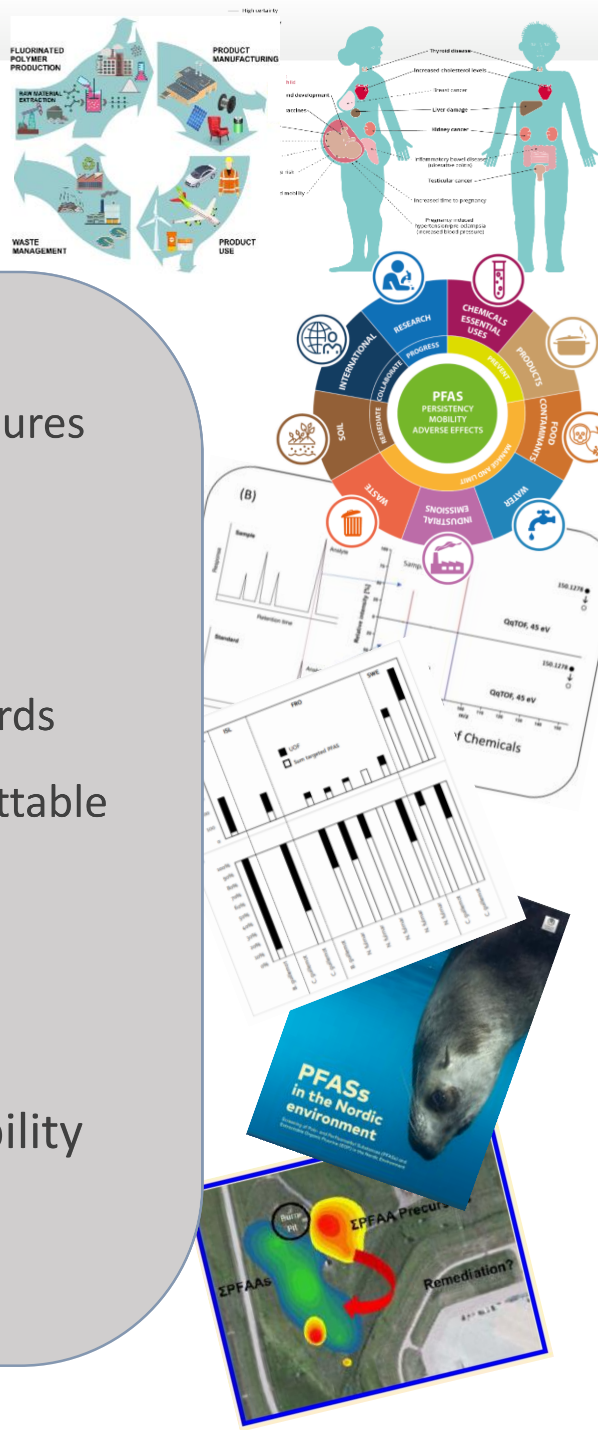
	PRO	CON
Remediate pollution	Lower environmental pollution and impacts	Risk of mobilising pollution
	Keep ecosystem resources clean for future generations	Damage ecosystems/nature?
		Energy/water/soil intense
		Very costly
		Efficiencies of clean-up methods vary
		Waste from clean-up has to be managed
Contain hot-spot pollution, clean-up medium/less polluted points	Allows to prioritize remediation efforts	Loss of clean soil/water and ecosystem resources for future areas
	More resources to cleanup where there is risk to e.g. drinking water, food?	Creates ‘sacrifice’ areas and communities that may be stuck

PFAS dilemmas: Clean up to which level?

	PRO	CON
Down to background levels	As required by law (e.g. in Denmark); since PFAS is anthropogenic background level is zero	This may be below levels in rainwater
	Protects against unknown/likely risks from persistent PFAS that will accumulate and mixture effects	Very expensive
		All sites have to be cleaned up, given widespread contamination
		Takes resources from other activities that may protect health of environment and people more
Above some action level?	Allows to prioritize remediation efforts	Not in compliance with the law
	Precedence exists from e.g. metals in food	Risk of lowering protection and prevention of pollution

Outlook and Conclusions

- **Chemicals surround us** – risks determined by hazards and exposures of combined exposures
- **Chemicals of concern: Irreversible pollution/effects**
  Most hazardous (bioactive), chemicals and effects that accumulate (persistent chemicals)
- **Coherence of legislations lacks**
  => align industrial emission legislation with environmental and drinking water/food standards
- **Multiple dilemmas**: What to monitor/by which method, remediate to which level, regrettable remediation, who to bear the costs of clean-up?
- ***Sufficiently* performing methods needed for more matrices**
- **Prevention of (non-essential) uses of most harmful substances is critical**
  - particularly in a circular economy faced by climate change and political instability
  - focus on innovation of safe and sustainable by design alternatives



Thank you for your attention!

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- UCPH colleagues/ group of Prof. Jan H. Chistensen!

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